OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **G482**: Electrons, Waves and Photons

Advanced Subsidiary GCE

Mark Scheme for June 2015

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations

Available in Scoris

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error or repeat error
SF	Error in number of significant figures
	Correct response
AE	Arithmetic error
	Wrong physics or equation

The abbreviations, annotations and conventions used in the detailed Mark Scheme are:

Annotation	Meaning
/	Alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

CATEGORISATION OF MARKS

The marking scheme categorises marks on the MABC scheme

B marks: These are awarded as <u>independent</u> marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answer.

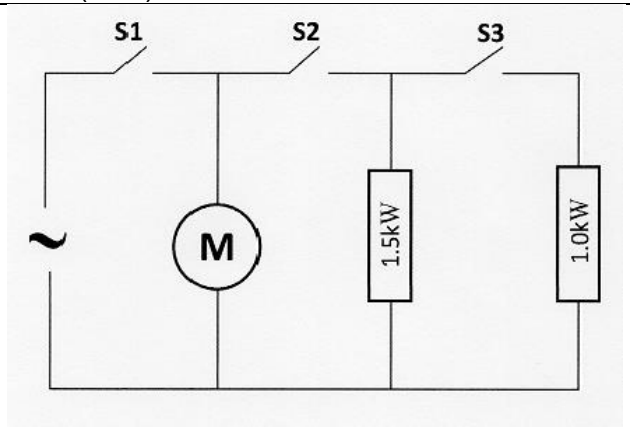
M marks: These are <u>method</u> marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answer. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows that the candidate knew the equation, then the **C**-mark is given.

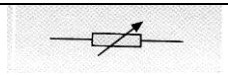
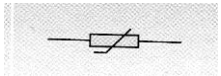
A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:
If the data given in a question is to 2 SF, then allow answers to 2 or more SF.
If an answer is given to fewer than 2 SF, then penalise once only in the entire paper. **N.B.** Also penalise RE only once per paper.
Any exception to this rule will be mentioned in the Guidance.

A tick should be placed in the body of the script at the point where each mark is awarded.

Question			Answer	M	Guidance
1					
	a	i	$P = V^2/R = 230^2/R = 1500$ $R = 35.3\ \Omega$	C1 A1	**accept** $I = P/V = 6.52$ A and $R = 230/6.52$ **allow** $52900/1500 = 35\ \Omega$, i.e. some working shown
		ii	use of $\rho = RA/l$ or $R = \rho l/A$ $l = 35 \times 7.8 \times 10^{-8}/1.1 \times 10^{-6}$ $l = 2.5$ (m)	C1 C1 A1	formula correct substitution answer (2.48)
	b		resistors and motor wired in parallel to supply switches correctly placed (open or closed) any suitably labelled symbols; components in correct order	B1 M1 A1	 do not expect switches to be labelled
	c	i	power is inversely proportional resistance (for same V) resistance of wire is inversely proportional to c-s area/diameter squared (as l and ρ are fixed/same)	B1 B1	**accept**: (same V so for) larger/smaller power need (larger/smaller I and so) smaller/larger resistance **accept** smaller c-s area/diameter (of wire) causes larger resistance or vice versa
		ii	P α A (because $P = V^2/R = V^2A/\rho l$) **or** P α d^2 (because $A = \pi d^2/4$) $1.0/1.5 = (d/D)^2 = 2/3$ so $d = 0.82\ D$	B1 M1 A1	**accept** $R_{1000} = 52.9\ \Omega$ and R α 1/A [where $A_d = 5.2 \times 10^{-8}$ & $A_D = 7.8 \times 10^{-8}$] so $35.3 / 52.9 = [(d/D)^2$ or $A_d/A_D] = 2/3$ [where $d = 2.57 \times 10^{-4}$ & $D = 3.15 \times 10^{-4}$]

Question			Answer	M	Guidance
	d		total current in circuit = 2600/230 = 11.3 A so 13 A fuse required	M1 A1	**accept** I = 2500/230 = 10.9 A
	e	**i**	(a unit of) energy equal to 3.6 MJ **or** 1 kW for 1 h/AW	B1	**e.g.** 1000 W for 3600 s or similar; **NOT** 1 kW **per** hour
		ii	1.6 x 4 x 18 115 (p)	C1 A1	**allow** 1 mark for 108 p; i.e. using 1.5 x 4 x 18 **or** 1 mark for 79 p; i.e. using 1.1 x 4 x 18 **NOT** 72 p
			Total question 1	**18**	

Question			Answer	M	Guidance
2					
	a		 for R_1  for R_2	B1 B1	
	b	i	500 Ω	B1	**accept** ± 20 Ω
		ii	7.0 = I x 500; I 0.014 (A)	B1	**ecf b(i)**
		iii	5.0 = 0.014 x R or 12 = 0.014(500 + R) R = 360 Ω	M1 A1	**ecf b(i)(ii)** **allow** R = 500 x 5/7 = 360 Ω
		iv	(at 200°C) R_{th} = 250 Ω V across thermistor =12 x 250/(250 + 350) = 5.0 V **alt** 5.0 = 12 x R/(R + 350) **or** I = 7.0/350 = 0.02 A; V_{th} = 5.0 = 0.02 x R R = 250 Ω which occurs at 200°C	B1 B1	**allow** R_{th} = 250 ± 10 giving 4.8 to 5.1 V **expect** 350 or 360; **allow** 1 SF where answer is 5.0 **NOT** 250 x 0.02 = 5.0 V; 0.02 A must be justified **allow** 7.0 = 12 x 350/(350 + R)
	c		**switch on** 5.0 = 12 x 250/(250 + R) or 7.0 = 12 x R/(250 + R) giving R = 350 Ω which is 190°C **switch off** 7.0 = 12 x 250/(250 + R) or 5.0 = 12 x R/(250 + R) giving R = 180 Ω which is 210°C **or** Switch on, R2 / R1 = 7/5 giving R2 - 250 x 7/5 = 350 ohm Switch off, R2 / R1 = 5/7 giving R2 = 250 x 5/7 = 179 ohm	M1 A1 M1 A1	**accept** solution in 2 stages first calculating currents on I = 0.02 and R = 7/0.02 off I = 0.028 and R = 5/0.028 **allow** ± 5°C in reading from graph **N.B.** zero marks for correct temperatures quoted without some correct working/justification
			Total question 2	**12**	

Question			Answer	M	Guidance
3					
	a	i	Q = It= 0.45 x 4.67 x 60 x 60 = 7600 C or As	C1 A1 B1	**accept** 7560 or 7570
		ii 1,2	**1** positive; **2** clockwise energy must be transferred to the cell **or** current in opposite direction transfers energy from the cell to the circuit/AW	M1 A1	positive plus correct direction of arrow for first mark; do not penalise if arrow not labelled I. **allow** (conventional) current is from positive to negative ; **or** electron flow from – to + [but current must be clockwise in **1**]
		3	V_{XY} = 1.5 + 0.45 x 0.90 V_{XY} = 1.9 (V)	C1 A1	**accept** 1.905 or 1.91
		4	P = VI = 0.45 x 1.5 P = 0.675 (J s^{-1})	C1 A1	**allow** QV/t with **ecf a(i)** if necessary (11340/16800) **allow** 0.7 as final line if 0.675 appears above
	b		**1.**cell across variable resistor R ammeter in series and voltmeter in parallel across R or cell **2.**Take (set of) readings of V and I for different positions/values of the variable resistor **3.**plot a graph of V against I **4.**(find) y-intercept = E **5.**(find) the gradient of the V against I graph which equals the internal resistance in magnitude **or 4 or 5** take one pair of values of V,I and substitute into equation E = V + Ir to find r or E	B1 B1 B1 B1 B1	QWC last marking point needed for full marks **allow** use (digital) voltmeter across unloaded cell to find E; add R and find one value of V and I; then use equation to find r (points 2 to 5) **ignore** sign of gradient in determining r **allow** for no graph plot, using 2 pairs of values of V and I substituted into equation allows r and E to be found.(points 2 to 5)
	c	i	4 x 1.5 V cells gives 6.0 V with r of 3.6 Ω so current is 6.0/(3.6 + 18) = 0.28 A requires (2 W/6 V =) 0.33 A to light normally or power delivered = (0.28^2 x 18 or 5.0 x 0.28)= 1.4 W **alt**: use 0.33 A & 6 V to show need emf of 7.2 V (1.8 V per cell)	B1 B1 B1	**allow** AW such as: 6 V but total R now 21.6 Ω; 6 V across 21.6 Ω gives 5 V across 18 Ω; requires 6 V to light normally **allow** P = 1.(6)7 W for 2 marks; only give the third mark if P labelled as power delivered by cell
		ii	1.5 n = 0.33 (18 + 0.9 n) **or** 1.5n = 6 + 0.3n so 3.6 n = 18 **or** 1.2n = 6 giving n = 5	M1 A1	**alt:** lamp needs V = 6V and I = 0.33 A terminal p.d per cell is 1.5 = V + 0.9 x 0.33 giving V = 1.2 V so n = 6/1.2 = 5 **allow** trial and error method but working must be shown to score any marks
			Total question 3	**19**	

Question			Answer	M	Guidance
4					
	a	i 1	the maximum displacement from equilibrium or rest position	B1	**allow** *zero* or *undisturbed* for *equilibrium*
		2	number of oscillations/vibrations (at a point) per unit time	B1	number of wavelengths passing a point or produced by the wave source per unit time **allow** per second **NOT** *amount* for *number*
		3	how far 'out of step' (out of sync) the oscillations at two points on the wave/string are/AW	B1	**alt e.g.** the fraction of a cycle between the oscillations at the two points
		ii 1	all have same frequency **or** same amplitude	B1	**N.B.** withhold mark if extra incorrect answers given
		2	all have different phases/ phase differences	B1	**allow** *not in phase* or *all out of phase*
	b	i	*progressive* a wave which transfers energy *stationary* a wave which traps/stores energy (in pockets) **or** *progressive* : transfers shape/information from one place to another *stationary* where the shape does not move along/which has nodes and antinodes/AW	B1 B1	**accept** phase relationship descriptions between different points on wave; must be a comparison for same property to score both marks
		ii	the wave reflected (at the fixed end of the wire) interferes/superposes with the incident wave to produce a resultant wave with nodes and antinodes/no energy transfer	B1 B1 B1	
		iii 1	**(all** points have) same frequency	B1	
			P and **Q** have same amplitude and (are in) phase	B1	**allow** *same phase difference* here
		2	**S** has larger amplitude than **P** and **Q**	B1	**allow** *different to*
			S has a phase difference of π/in antiphase to **P** and **Q**	B1	**or** 180^{o} **max** any 3 out of 4 marking points
		iv 1	15 Hz	B1	
			as all points in the fundamental/first harmonic mode move in phase	B1	**accept** string is ½ λ long/between ends
		2	120 Hz	B1	
			for every 10 cm to be at rest λ = 20 cm (so 4 x frequency of Fig. 4.2)	B1	**accept** as all points are nodes **or** $f = 8f_0$ **or** is 8^{th} harmonic
			Total question 4	**17**	

Question			Answer	M	Guidance
5					
	a	i	when two (or more) waves meet/superpose/overlap (at a point) there is a change in overall displacement	M1 A1	**NOT** interact,combine, join, connect, collide, hit**,** intersect, pass through, etc. **allow** the resultant displacement equals the sum of the individual displacements
		ii	constant phase difference/relationship (between the waves)	B1	**allow** fixed **not** same
	b		$\lambda = c/f = 3.0 \times 10^{8} / 1.0 \times 10^{10}$ $\lambda = 3.0 \times 10^{-2}$ so aerial length = 1.5×10^{-2} (m)	M1 A1	 **accept** 1.5 c(m)
	c	i1	the path difference between the signals (from the two transmitters) changes (along OP) causing the detected signal to vary between maximum and minimum values/AW **or** when signals (at the point on OP) are in phase there is a maximum when (π) out of phase there is a minimum	B1 B1	**give** 1 mark out of 2 for maxima and minima occur (because of interference)
		2	$x = \lambda D/a = 3.0 \times 10^{-2} \times 4.0/0.20$ (= 0.60) so distance = x/2 = 0.30 (m)	C1 A1	**ecf (b)** 20 times answer to **(b)** **allow** 1 SF answer here
		ii	amplitude of signal decreases (inversely) with distance because energy emitted by the transmitters spreads out (so less is collected by the receiver the further away it is)	B1 B1	**allow** intensity; **no mark if** any suspicion of decrease being caused by interference effect **accept** any statement which conveys the idea of energy spreading correctly,e.g. $I \propto 1/d^2$
		iii	when AO – BO = λ/2 a minimum occurs/AW **or** phase difference of π (180^{o}) between detected signals from A and B so distance = λ/2 = 1.5×10^{-2} (m)	B1 B1	idea that movement of λ/2 will change maximum to minimum or vice versa **ecf (b)** same answer as **(b); accept** 1.5 c(m)
	d	i	intensity increases by factor of 4 as intensity α (amplitude)^2	B1 B1	
		ii	intensity falls to zero (emitted) signal is (vertically) polarised receiver in position only to detect horizontally polarised signal	B1 B1 B1	 **allow** transmitter and detector act like 'crossed polarisers' or quoting Malus' law correctly
			Total question 5	**18**	

Question			Answer	M	Guidance
6					
	a		photoelectric effect	B1	
	b		**1.**Individual photons are absorbed by individual electrons (in the metal surface)/ one to one interaction/AW **2.**Only photon with energy above the work function energy will cause photoelectron emission/idea of threshold frequency **3.**Photon energy is proportional to frequency **4.**(therefore) blue photons with higher f/shorter *λ* will cause photoemission but red photons will not. **5.**hf – ϕ = KE_{max} is the equation resulting from conservation of energy **or** resulting from the meaning of each term **6.**A wave model does not explain instantaneous emission	B1 B1 B1 B1 B1 B1	**max** 4 from 6 marking points **allow** work function (of a metal surface) is minimum energy for photoemission **allow** shorter wavelength light has higher energy (hc/ *λ)* or higher frequency higher energy (hf) **or** ….red photons with lower f/longer *λ.....* *max* must be present to score mark; equation stated in words: photon e. – w.f. = max ke of *e* to score full marks (4) the answer **must include** two terms out of *photon, work function* and *threshold frequency/wavelength* (QWC mark)
	c	i	work function = ϕ = hc/*λ* φ = $6.6 \times 10^{-34} \times 3.0 \times 10^{8} / 4.8 \times 10^{-7}$ = $4.1(4) \times 10^{-19}$ (J)	C1 M1 A1	allow ϕ = hf (f = 6.25×10^{14}) and f = c/*λ* must show answer <u>initially</u> to 2 or 3 SF; ignore any <u>final</u> rounding down to 1 SF
		ii	E - ϕ = ½ mv^2 $(5.2 – 4.1) \times 10^{-19} = 1.1 \times 10^{-19} = ½ mv^2$ $v = \sqrt{(2 \times 1.1 \times 10^{-19} / 9.1 \times 10^{-31})}$ $v = 4.9 \times 10^{5}$ (m s^{-1})	C1 C1 A1	can use 4.14 or 4 instead of 4.1 **allow** 5.1×10^{5} (m s^{-1}) using ϕ = 4×10^{-19} or 4.8×10^{5} (m s^{-1}) using ϕ = 4.14×10^{-19}
	d	i	electrons passing through a thin sheet of graphite are diffracted/produce diffraction rings on a fluorescent screen	M1 A1	any suitable/reasonably plausible situation what is observed/ interpretation
		ii	λ = h/mv $\lambda = 6.63 \times 10^{-34} / 5.0 \times 10^{5} \times 9.1 \times 10^{-31}$ $\lambda = 1.5 \times 10^{-9}$ (m)	C1 C1 A1	 1.46 to 3 SF
			Total question 6	**16**	

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